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2.00	Sports Review at the Hangar Gym: Boxing, Fencing, Wrestling, Gym.
2.30	Track Meet with University of Maine at Hangar Track Field. Lacrosse Game with Andover at Coop Field.
3.00	Technique Rush at the Hangar Track Field.
3.30–6.30	Tea Dance at Walker Memorial.
4.00–5.00	Officers' and Department Heads' Reception in respective offices.
7.00	Sports Review at the Hangar Gym: Boxing, Fencing, Wrestling, Gym.
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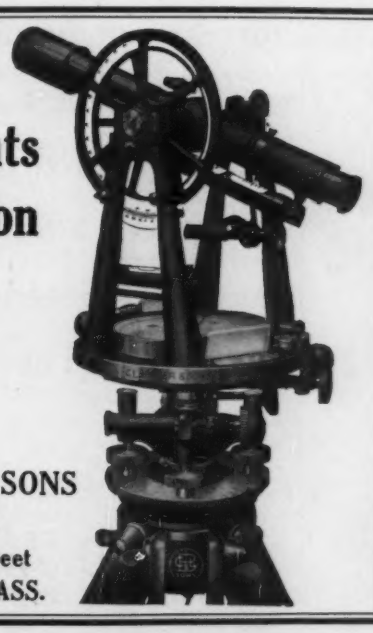

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A.M.

9.30 Assemble in lobby of new George Eastman Research Laboratory.

9.45 Greeting on behalf of the Institute. President Compton, Professor Jackson, and Professor Norton. Room 6–120.

10.15 Assignment to guides for tour of the laboratories.

P.M.

12.30 Start to Walker Memorial for Lunch.

1.00 Lunch in North Hall of Walker Memorial.

2.15 Continuation of examination of laboratories.

4.15 Informal tea. F. Jewett Moore Room, 6–319.

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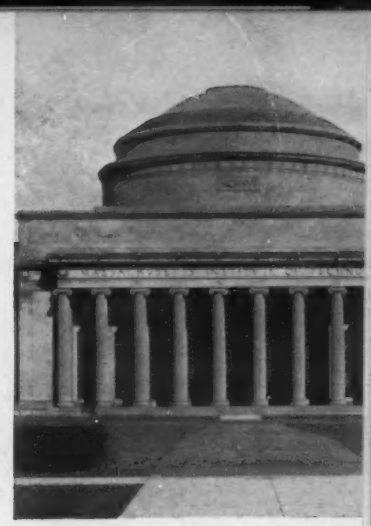

MAY, 1933
VOLUME XIV
NUMBER 4

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If this fail
The pillared firmament is rottenness,
And earth's base built on stubble.
—MILTON

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME XIV | MAY, 1933 | NUMBER 4

Looking Ahead At THE INSTITUTE OF TOMORROW *—Trends and Objectives*

By KARL T. COMPTON
President Massachusetts Institute of Technology

IN writing this brief article on the future of the Institute, my thoughts have been profoundly influenced by an attempt to imagine what our founder, President Rogers, would have written in his time on this subject, and how closely would his hopes and expectations have foreshadowed the Institute as it exists today. An examination of his writings gives a clue to the answer to this question, and hence to the manner in which I may appropriately discuss it.

If the early founders of the Institute could visit us today, they would recognize none of the staff and none of the students. They would be astonished at the laboratories and buildings. They would not understand a great deal of the subject matter of our instruction or research. They would not have heard of the honors courses, the rating system, the requirements for degrees, the Institute committee, or the alumni council. In fact they would be strangers to nearly all those things which are likely to come quickly into our minds when we think of the Institute. Yet I am greatly impressed with the wisdom and clarity with which these founders defined those things which are real and permanent in the Institute: its objectives.

The Objectives of the Institute were set forth when it was incorporated "for the purpose of instituting and maintaining a society of arts, a museum of arts, a school of industrial science, and aiding generally by suitable means the advancement, development, and practical application of science in connection with arts, agriculture, manufactures, and commerce."

If interpreted literally, we find every one of these objectives reflected in our activities. To be sure, our society of arts operates in a restricted field, our industrial museum as yet exists only in the numerous nuclei of exhibits at present scattered through the various departments, and our activity in agriculture is limited to the underlying basic science and occasional special research. Numerous professional and learned societies now fill the major needs for a society of arts, and the government has everywhere taken over the task of practical education and research in agriculture. A real museum of science and industry, built upon and extending our present scattered material, would have a fine educational influence in our own institution and in the entire community, and is much to be desired. The remaining objectives of the charter, *i.e.*, "a school of industrial science, and . , . the advancement, development, and practical application of science in connection with arts . . . manufactures and commerce" constitute an accurate description of our entire effort and achievement, past and present.

Deeper than this literal interpretation are the real spirit and purpose which found expression in the charter. President Rogers had a deep conviction of the value of science to human welfare. He had faith in its contribution to intellectual freedom, to economic and social betterment and to personal health, convenience and happiness. The fundamental ideal of the Institute is, therefore, *public service through science.* This will cer-

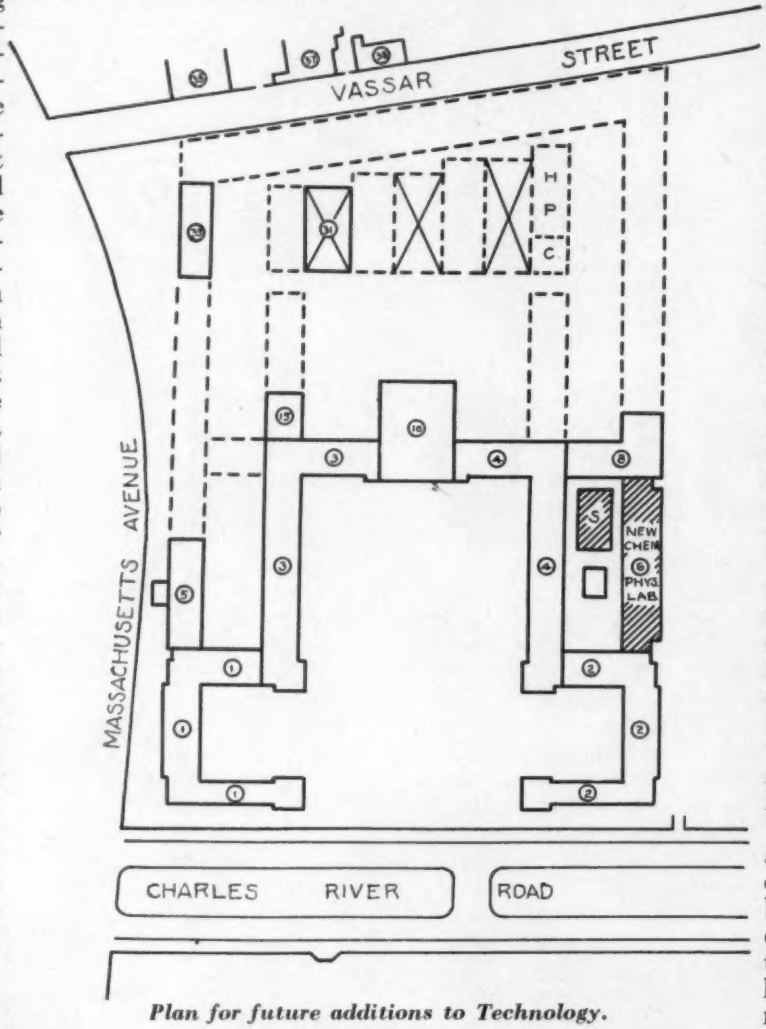
tainly continue to be our ideal in the future. Its possibilities are inexhaustible.

Certain Trends in the Institute exist as the result of the present state of development of pure and applied science, of the economic situation, and of our immediate background. These trends are to be interpreted as modifications in the manner in which the objectives will be most effectively attained in the near future. Most of them have already been the subject of recent discussions.

A greater emphasis on fundamental science and on the fundamental principles of engineering is made advisable by the increasing complexity of engineering practice and the increasingly rapid development of new technique and of new fields of application of science. It is impossible to crowd into a curriculum all the details which may possibly be needed in subsequent practice; and even if this were possible, an attempt to do so would defeat one of the greatest possibilities in our type of training, namely, a constructive and original approach to the solution of new problems. To this end I look for our curricula to be progressively modified to meet the changing conditions and in particular to become more simplified and to give rather more opportunity for individual initiative and expression on the part of the student without, I hope, diminishing the extent of his time and effort.

A greater emphasis on social and economic problems will be necessary for the engineer or architect of the future because modern society is so fundamentally affected by his work that he must view it and carry it on with an intelligent perspective of its social and economic significance. We have recognized this in an important way through the establishment of the Department of Business and Engineering Administration and the inclusion of economic and other studies in our curriculum. This aspect of the activity of our future graduates is relatively so important that I look for increasing attention to it as essential to maintaining our ideal of constructive leadership in the engineering and architectural fields.

Postgraduate work is destined to be of increasing importance in the future. This is the logical result of the increasing complexity of science and engineering. It is also an actual fact which can be demonstrated by graphs showing the relative increase in postgraduate instruction during the past decade. It is a tendency which is at present being artificially stimulated by the depression. This does not mean that we should gradually change into a purely postgraduate school. It is neither necessary nor desirable that all men should be trained to highest degree as specialists. For many important lines of activity this would probably be a disadvantage rather than an advantage. Consequently the traditional four-year, or in some cases five-year, college course will probably continue to be the backbone of our educational program. At the same time, however, it becomes increasingly necessary to train specialists. There is no educational institution in this country which has an opportunity equal to our own, through tradition, present facilities or future possibilities, for training the highest class of specialists in these fields. I look, therefore, for increasing relative emphasis on our postgraduate work.



Plan for future additions to Technology.

Research work will be increasingly important for three principal reasons; it is an essential part of the type of educational program which has been outlined above; it is a type of service recognized in our charter which is of the greatest importance to society and which no other type of organization is so well fitted to perform; in certain respects it offers a unique opportunity to perform a real service to "the arts, agriculture, manufactures, and commerce" as specified in our charter, while at the same time giving to our staff and to our students advantageous contact with productive organizations and their problems.

Education in pure and applied science will come more and more to be looked upon as an essential type of "cultural education" in its highest sense, since it is necessary to the proper understanding and appreciation of our environment and our adjustment to it. Consequently we may look for an increasing number of students who will take our type of education as a general training for life, irrespective of its particular possible application to professional work in one line or another. A survey of our alumni shows strikingly how successful such a training can be for non-professional as well as professional purposes. Of course not all "liberal education" can or should be of our type because not all men are similar or should be trained alike. We have, however, a great field for the general training of the boy who has an inquiring mind, a mechanical sense, or a constructive urge.

What Does the Institute Need in the Immediate Future? is a question whose adequate answer would far exceed the limits of this article. Fundamentally I should say that it needs above all else the intelligence, the will, and the coöperative spirit to utilize those resources which

(*Continued on page 81*)

OPEN HOUSE

Its History and Purpose

By DAYTON H. CLEWELL '33

Chairman Open House Publicity Committee

IN the spring of 1922, an evening was set aside by the mechanical engineering society of the Institute for visitors to inspect the steam and hydraulic laboratory, and thus was planted the idea of Open House as an annual event which was to grow in popularity until, in 1931, twenty-three thousand people attended it.

The Tech

In 1923 the Combined Professional Societies, influenced partly by the success of the demonstration the year before, and partly by the belief that it was desirable to provide an opportunity for the public to come and observe the progress being made in science and engineering, decided to have the first Open House at Technology. Plans were made to take care of between five hundred and a thousand visitors on the evening of Tuesday, May 8, 1923, the date set for the first visitors' night. The Boston Chamber of Commerce, the Associated Industries of Massachusetts, the Affiliated Technical Societies of Boston, the Boston Rotary Club, and the Taylor Society were especially invited to attend.

The visitors were divided into groups as they arrived and put in charge of seniors who served as guides and explained the details of the various exhibits. The wind tunnel and the electrical laboratory attracted the most attention although the steam and hydraulic laboratory was not far behind in catching the interest of a large number of visitors. Six hundred people attended, of which fifty per cent were women, forty per cent students and ten per cent business men — rather a surprising distribution.

Its publicity value and popularity being recognized, more elaborate plans were made for Open House the next spring. Three thousand guests attended this time and were conducted in groups to the Naval Architecture Museum, the testing materials laboratory, and of course the ever popular steam laboratory. The million-pound testing machine in the testing materials laboratory, together with the new lead-lined X-ray laboratory, were the principal exhibits of interest in 1924. The lead-lined X-ray room is still in the basement of Building 4 and is open for inspection at this year's Open House. Eight tons of lead are spread over the walls of the room to keep the penetrating rays from injuring anyone. Periscopes allow one to watch apparatus in operation from a safe distance outside the room.

In 1925 the Military Science Department carried away the honors by presenting the most spectacular demonstration. An article in an issue of THE TECH for April 17, 1925 runs thus: "A tank running behind a smoke screen, a dozen Very lights, nineteen high-power flares, and several eight-foot rockets comprised the Chemical Warfare Service demonstration which concluded the celebration of Open House last evening."

By this time Open House had become an established annual affair. People interested in the Institute were anxious for these opportunities to inspect the various laboratories at a time when they were in full operation. Students and administration, alike, were glad to continue the event the following year.

The governor of Connecticut in 1926, Hon. John H. Trumbull, was a special guest of the 1926 Open House. This year the ball-bearing testing machine in the machine tool laboratory and again the Chemical Warfare Service smoke screen proved to be very popular. For the first time the student activities held Open House in Walker Memorial.

The first four Open Houses were held on week-day evenings, but in 1927 so much interest was shown that it was decided to have the Institute open from 2 until 10 p.m., Saturday, April 30. The Combined Professional Societies in coöperation with the Faculty and the Administration presented a more complete Open House than ever before. Freshmen in uniform were called into service to guide the fifteen thousand visitors through the various laboratories.

By far the most interesting exhibit in 1927 was the perpetual motion machine in the machine tool laboratory. It consisted of a wheel mounted on clear glass rod supports to show there was no power being supplied to turn the wheel. And yet, with a number of steel balls pivoted to its spokes, the wheel turned continuously. The secret of the wheel's apparent perpetual motion lay in the glass supporting rods which were hollow and carried glass shafts connected to the wheel and driven by an electric motor concealed in the base.

Twenty thousand people attended the sixth Open House in 1928, showing how it was becoming more and more of an event which friends of the Institute were eager to attend. President Stratton held an informal reception in the Main Foyer during the evening and many people went through the receiving line to meet officials of Technology. The liquid air demonstration and the photo-ukulele attracted considerable attention this time. The latter was a drawing card because everyone was curious to see the mysterious new photo-electric cell in its rôle of a magician.

At the 1929 Open House, a presentation of a cross-section of student life at Technology made a new and interesting feature. For the first time the annual Technique Rush was held on the same day, a picked freshman drill company executed a guard mount, and a

(Continued on page 83)

The Trend in UNDERGRADUATE ACADEMIC OPPORTUNITIES *At Technology*

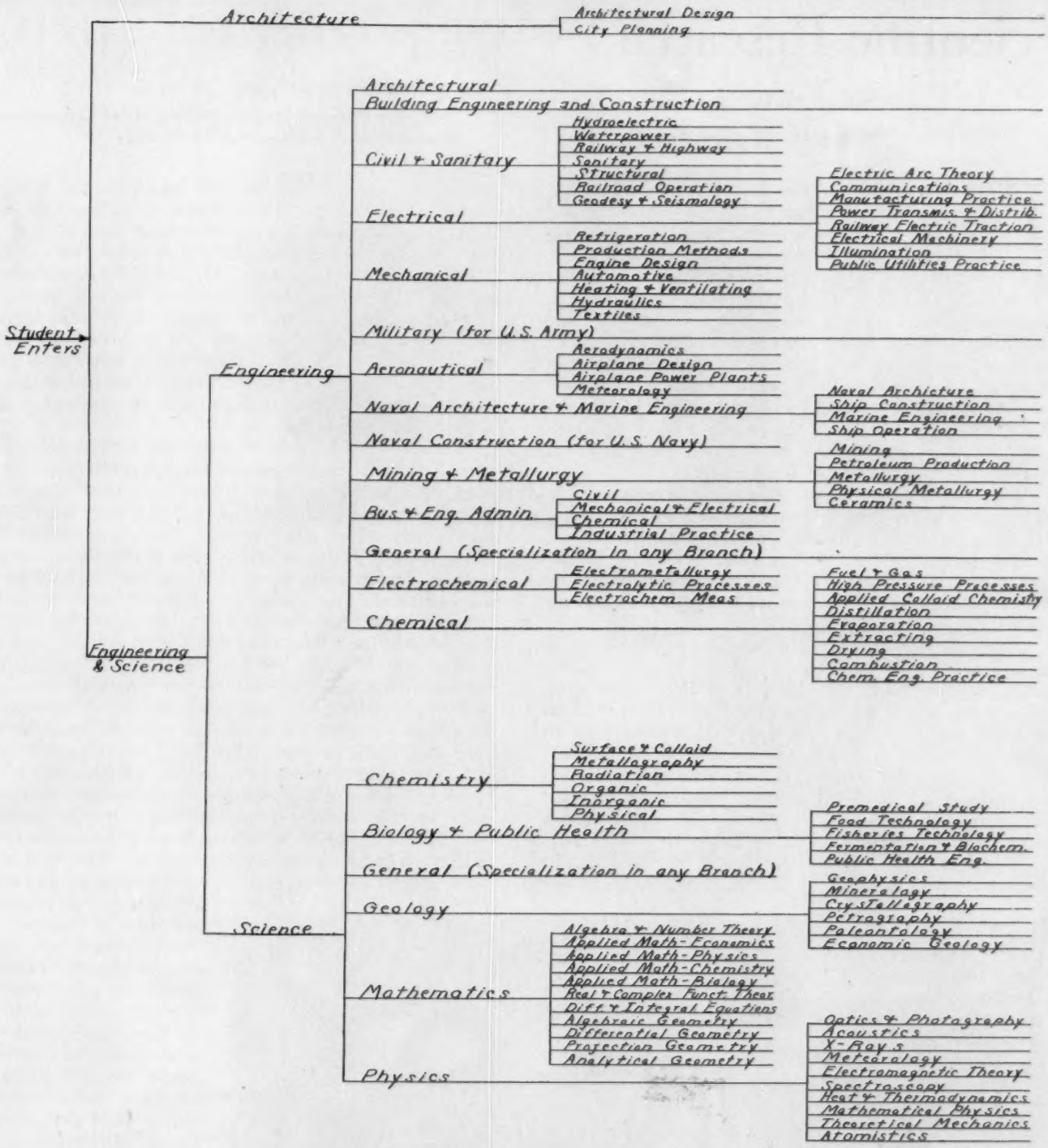
By VANNEVAR BUSH
Vice-President
Massachusetts Institute of Technology

THERE are many misconceptions in regard to that complex affair, the academic life of the undergraduate at the Institute. It is certainly complicated, and even among the present student body there appears to be a lack of complete appreciation of its manifold possibilities. Too often the career of an undergraduate is dictated by chance rather than by reasoned consideration of the problem before him. This paper has nothing to do with those extra-curricular activities which are so important in a properly rounded-out college experience, although these warrant serious consideration and study by any undergraduate if he is to make the most of his opportunities. Rather, it is the purpose of this discussion to present the strictly academic opportunities which lie before the undergraduate and from which he selects his field of study.

Technology Review

There is now at the Institute an arrangement whereby the selection of a career becomes a progressive affair. This has properly been modified by the Faculty recently in order to give the undergraduate a more gradual introduction into his chosen field, and a greater opportunity to consider just where his aptitudes should lead. When a freshman enters the Institute it is not necessary that he should have made a decision in regard to his ultimate goal, although it is highly desirable that he should always have a definite goal before him and be willing to alter his objective as he gains maturity. Unless the student plans to enter the fascinating field of architecture, his studies during the first year are the same for any course. Beginning with the second year, however, he chooses between the two broad fields of science and engineering. At the beginning of the third year, he enters upon a department of study in either science or engineering, and while he may have taken one course in a chosen field during his sophomore year, it is still possible for him to change his particular branch of science or engineering in accordance with his maturing inclinations. In the third and fourth years comes the possibility of a higher degree of specialization and usually a choice of options. Finally, in graduate work, the specialization may be carried to the point where the student himself reaches an outpost of knowledge and takes his part in advancing the frontier. Thus the program fans out and exhibits that form of growth which is inherently an evolution from the general to the particular.

The final situation may bring a man into any one of a number of diverse fields of interest, ranging from business administration through the various branches of engineering to numerous fields of science. There are many courses of study possible without departing from prescribed curricula and regular procedure. Moreover, there is a provision whereby those who have special interests may find even greater freedom and pursue courses of study which may for one reason or other be of peculiar interest or attraction. This can come about in two ways. Heads of departments may make substitutions, and are glad to do so in the case of any student who has good records and a clear-cut objective, so that he may include in his course subjects not in the regular program, but for which he has a particular bent, omitting other parts which are of lesser interest to him. The extent to which this is possible is certainly not appreciated by the student body, or else they are giving less considerations to their own careers than is desirable, for the amount of such substitution is not large. Perhaps this comes about because the regular courses available are sufficiently diversified without this additional feature, although undoubtedly it could be advantageously utilized in many situations where it is not now employed. Moreover, there is a course called General Science and General Engineering. It is intended to be a provision whereby a student of promise may depart entirely from the prescribed curricula and select his own course of study with the approval of a Faculty committee which supervises this course. It is not a refuge for those who cannot make the grade elsewhere, but is definitely an opportunity for those of ability who have unusual objectives or desires. Thus, out of about twelve hundred subjects offered in the catalogue, it is possible for any student, provided he has satisfactory records, to construct almost any course at will, provided only that it forms a well-balanced program and has reasonable sequence, and hence may be properly approved by the Faculty. Some forty regular courses of study have been



FIELDS OF STUDY

A suggestive diagram of some of the fields which a student may enter upon, as undergraduate or graduate student, at the Massachusetts Institute of Technology.

defined to meet the usual needs, but there is thus also a provision for exceptions.

This may appear to be an extreme amount of specialization in an undergraduate career, and in a certain sense, it is. It should be considered, however, in the light of the underlying philosophy of the institution. First and foremost is the idea that the Institute is a place for men to work and not for boys to play, as was aptly stated by President Walker. Second, it is the reasoned opinion of the Faculty that it is possible to have a high degree of specialization without undue loss of breadth of culture. After all, it does not make so much difference what a man studies as how he studies and with whom he studies. The primary object of an educational institution is to provide an atmosphere in which students and staff may work together on matters in which they have a mutual interest. The same fundamental ideas of science underlie all of the various branches, both of science and engineering, although the relative emphasis may vary in different fields. Specialization is highly desirable as it produces an intense interest on the part of both students and staff. It is not narrowing if the same fundamental scheme runs throughout. It must be remembered that it is rather difficult to merely work intensely over long periods, whereas it is a fascinat-

(Continued on page 80)

Scientific Research

—*Its Value to the Small Manufacturer*

By EARL B. MILLARD
Assistant Director Division of Industrial Coöperation
Massachusetts Institute of Technology

THIS discussion of research and the small manufacturer will refer mainly to those who employ less than about one hundred persons in the production of one or several articles which must meet specifications of quality, and which are sold in a competitive market. It is taken for granted that the manufacturer is anxious to improve these products from time to time, or to make others better suited to the same uses, and that these developments give rise to a variety of problems. It may be further assumed that the manufacturer will consider research to be anything which tends toward the solution of these problems, whether or not such work involves a material extension of the bounds of knowledge.

The circumstance which impels a manufacturer to seek the aid of research is frequently one which he himself does not wish to discuss or cannot explain; for it sometimes relates to a falling sales curve, or to the appearance of a competitive article which may not be better than his own, but which is threatening his volume of sales.

Since the Institute's main function is education, it should accept only problems which are in some degree useful in broadening the interests of those who work upon them, unless its facilities for the work are not to be found anywhere else. It should give preference to work, the results of which will be suitable for publication; and it should accept "closed" research (of which the findings are disclosed to only one person or firm) only upon the basis of a fee which is no lower than a commercial laboratory would charge.

Whether the manufacturer brings his problem to the Institute or takes it to any other place, there is a strong probability that he will require some guiding before experimental work is begun. If he has had only slight scientific training or none, and especially if he has followed the news accounts of research, his faith in science knows no bounds. He reads of accomplishments approaching the miraculous through research applied to industry, and of discoveries in pure science which range from the infinitesimal to the infinite. His own situation is well adapted to the immediate performance of just such another miracle, and with this in mind he may arrive in a high state of expectancy and slightly out of breath.

It may be necessary to point out to one in such a condition that science has indeed no limitations, or at least its devotees will admit none, but that those who practice science are sometimes subject to at least three limitations which may restrict their availability for his problem. These are time, research facilities (or the money for acquiring them at once), and experience in his immediate field. This last difficulty is at the same time the most common to arise, the most shocking to the manufacturer, the most difficult to explain, and the easiest to overcome. For how, he may ask, can a great school with a teaching staff of five hundred members, with unexcelled equipment, an Institute of *Technology*, be without a technologist familiar with the manufacture of coated wire! (or pasting machines, paper bags, elliptical gadgets, or nephoscopes, as the case may be).

As a matter of fact, minute specialization such as he asks or expects would be deadening to the broader scientific atmosphere which equips any research organization to handle a variety of problems. The method of attack upon any problem is much the same as that upon any other. A qualified physicist or engineer or chemist with an open mind and broad scientific experience may be relied upon to acquire and sift the facts and to devise experiments which will locate the difficulties or point to more suitable means of so doing. Such a scientist is indeed much more likely to do this at once than is a man closely associated with all the details of manufacturing. The man who could not find the forest because of the trees was not a good research worker.

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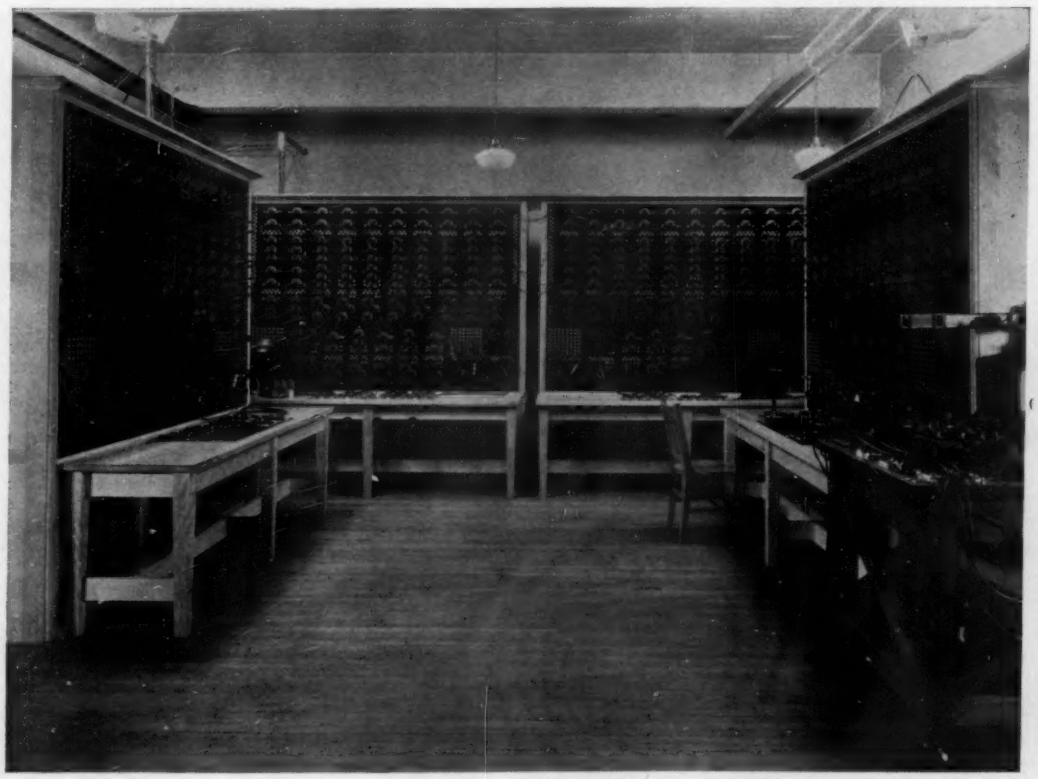

The Institute's network analyzer, which has solved many electrical problems submitted by power companies.

Controlled Atmosphere:
—*Air Conditioning Enters the Home*

By VINTON K. ULRICH '35

MAN has long striven to protect himself from the elements by building himself a shelter. Today he is trying to control the "weather" inside his home or place of work, but up to the present his efforts have been almost entirely confined to the problem of keeping warm in the winter. With the recent introduction of numerous types of air-conditioning devices, the problem of creating an ideal "weather" in the home has been greatly simplified.

Frigidaire Corporation

The unit type of air-conditioning plant can be installed almost anywhere in the home.

Air conditioning is the simultaneous control of proper temperature, humidity, and air movement, together with a reasonable air purity. Keeping the atmosphere of the home within certain desired limits not only keeps the occupants comfortable in the most disagreeable weather, but also aids in gaining and maintaining good health. No one will refute the statement that the substitution of a fairly constant temperature for a rapidly varying one, the elimination of drafts, and the purification of air by filtration to remove dust particles and other impurities, will be a great benefit to a person's health. A benefit of air purification which is not usually recognized is that soiling of furniture, draperies, and walls is practically eliminated, and the costs of cleaning and replacing will be notably reduced.

The art of air conditioning breaks up mechanically into three parts — *heating*, *ventilating*, and *refrigeration*. The first two are already well advanced as concerns low cost and economical operation. Our methods of heating have steadily advanced from the old-fashioned fireplace of our forefathers to the compact modern gas and oil-fired boilers of today. Ventilators have reached a high state of perfection and efficiency for both the home and larger installations. Humidifiers are in common use, playing an important part in industry, public buildings, and the home. Refrigeration, essential to produce and maintain cool temperatures in the summer, constitutes a somewhat difficult problem, but cooling devices of various natures are now coming into the foreground as practical and necessary equipment for the well-appointed home.

One of the first limitations we find imposed upon the practice of air conditioning for the domestic user is the matter of insulation. Unless the interchange of heat and cold between the rooms to be conditioned and the outside atmosphere can be controlled, it means fighting a losing battle.

With new construction this problem is relatively simple, for the science of building has progressed so far in the past few years that adequate insulating materials can be secured at reasonable prices. No revolutionary changes in architectural design are involved in securing insulated homes. It will not be necessary to see an era of windowless houses, blank-walled dwellings and apartments. Well insulated walls, double-glazed sash, and the control of air intake and discharge are all that will be required.

To have efficient conditioning, air circulation must be controlled; the unregulated opening of doors and windows will be a thing of the past, for to do so would only interfere with the planned air circulation and defeat the very results aimed at. These are but mere problems in design, and buildings constructed with air conditioning in view will be arranged so as to avoid these undesirable results.

With existing structures, a more complete problem is presented. It will be found that some can be adapted to the installation of air-conditioning equipment at small expense, while others might not justify the cost entailed.

There are two distinctive ways of installing air-conditioning equipment which can be followed. The first is a centrally located machine usually placed in the basement. The other is to place unit coolers in each room to be controlled. With the central type a number of ducts are used to circulate the conditioned air to the numerous rooms in the house, or else a system for piping a refrigerant to a radiator and fan which circulates the air about the room is employed. When ducts are used it is customary to have the intake and outlet mounted be-

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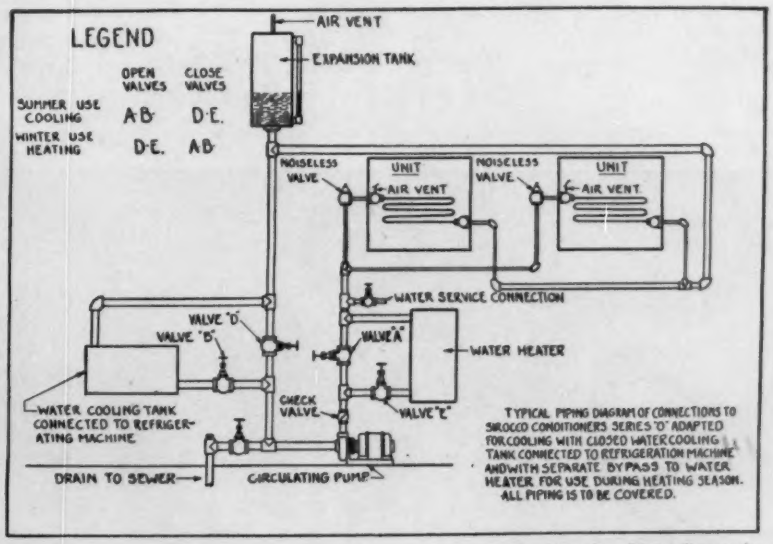
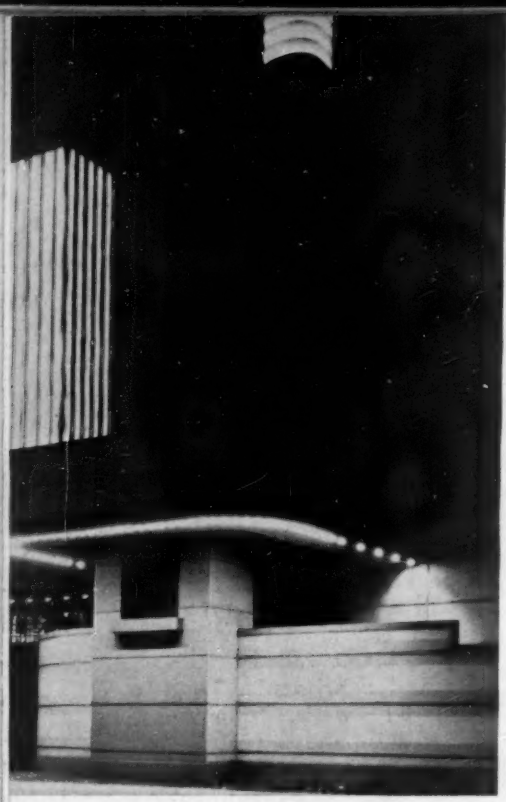


American Blower Corporation

This type of air-conditioning system heats the home during the winter and cools it during the summer.



Exposition buildings illuminated at night.

Novel Displays Teach SCIENCE AT THE WORLD'S FAIR *—A Royal Road to Knowledge*

IF there is any science in which the axiom that there is no Royal Road to it would seem to be firmly established, that science is mathematics.

Taking the untrained mind into the realm of abstract mathematics by means of readily understandable moving exhibits is an undertaking that might stagger any scientist-educator.

However, that apparently insuperable task has been undertaken and will be carried at least some distance toward success at A Century of Progress, the Chicago World's Fair of 1933.

This is the age of visualization. A Century of Progress undertakes to carry visualization in action further than ever before has been attempted. The purpose of the Exposition is to show the progress of science and its application to industry and all aspects of life. To show this advance of mankind and to open a vision of the future, not by motionless displays, but, to the greatest possible extent, by moving exhibits showing actual processes in action, is what will distinguish this Exposition from any other of the past.

That problem had to be faced squarely by the Basic Sciences Division of the Department of Exhibits. It is our belief that the problem has been met in a way that will have a definite effect on education.

The impression must not be given here that a visit to the chemical section, for example, in the beautiful Hall of Science will give the layman a complete course in chemistry, but it is the plan that he shall be given a general picture of the science.

Basic Sciences Division of the Department of Exhibits was created at the suggestion of the Science Advisory Committee of the National Research Council. Chief of the Division is Dr. Henry Crew, on leave of absence from the Fayerweather professorship of physics at Northwestern University.

For exhibition purposes an arbitrary classification of the sciences was made, as follows: Mathematics, Astronomy, Physics, Chemistry, Biology, Geology, and Medical Science. A "section" was assigned to each science. The section head must be a scientific specialist, designer, instrument maker, inventor, headline writer, and stage director. A wealth of material has been furnished by the various subcommittees of the Science Advisory Com-

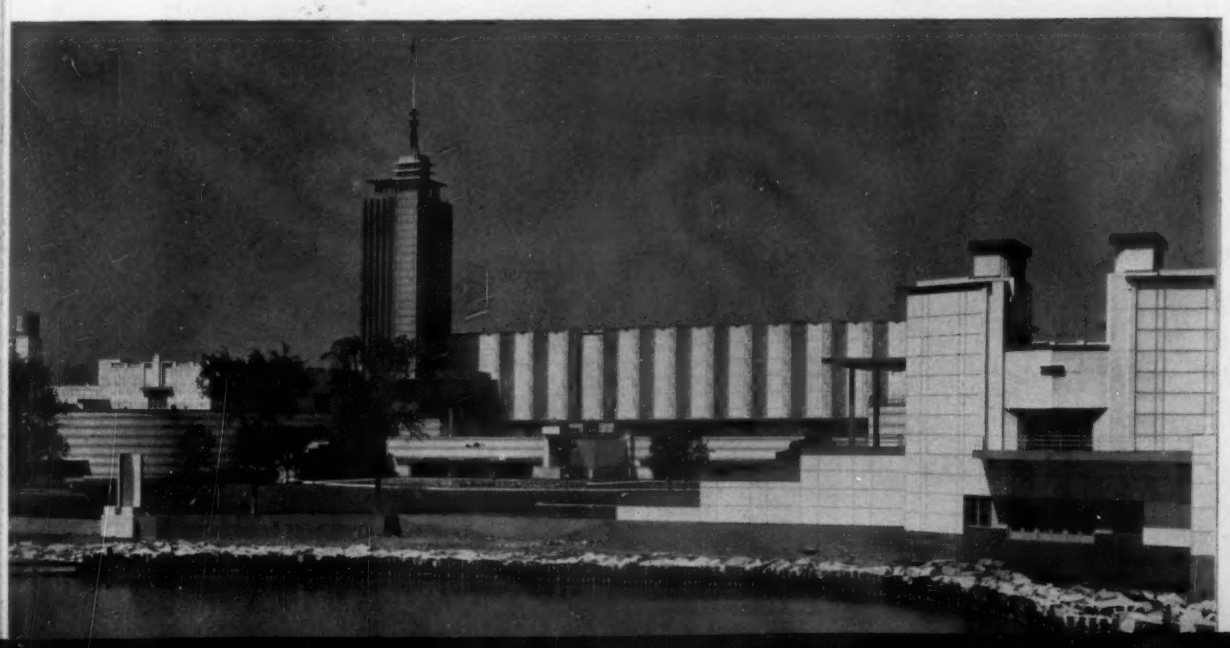
Foreword

The contributions of science to human progress during the past century have been greater than in all the previous history of the world combined. A Century of Progress Exposition will attempt to interpret these contributions to man's advancement in a manner that will be intelligible to the average person.

Scientists within the organization of A Century of Progress have evolved methods of presenting exhibits of science that are unique, graphic, and entertaining, even to the lay mind. Even such an abstruse thing as mathematics has been made understandable as a result of their efforts.

Major Chester L. Fordney, United States Marine Corps, is one of the accomplished members of our research staff who has worked for many months on these novel presentations, and is in my opinion entitled to a feeling of pride in telling of their exhibit.

(Signed) RUFUS C. DAWES, *President*
Century of Progress Exposition.



The Hall of Science, in which will be displayed the mathematics exhibits.

Engineering News-Record

By CHESTER L. FORDNEY
Major United States Marine Corps

mittee. Exhibits being required to be to the limit of possibility of the moving "dynamic" type, apparatus had to be devised to exhibit the phenomena selected for illustration. The Exposition is to last one hundred fifty days and the apparatus had to be sturdy and simple enough to minimize the possibility of breakdown.

It is estimated that fifty million persons will visit A Century of Progress International Exposition. In such a number of individuals there will be found a wide range of intelligence, training, and appreciation. If the scientific exhibits are to be of such a nature that they appeal only to persons of scientific training the number interested will be small indeed. If the exhibits are merely "popular" the Exposition will not have kept faith with those scientists who have given so generously of their time and effort.

A general picture of science must be given, yet the show must not degenerate into mere "fireworks," as Dr. Jewett remarked in his Hall of Science dedicatory address. The scientific exhibits must be true. There can be no charlatanry.

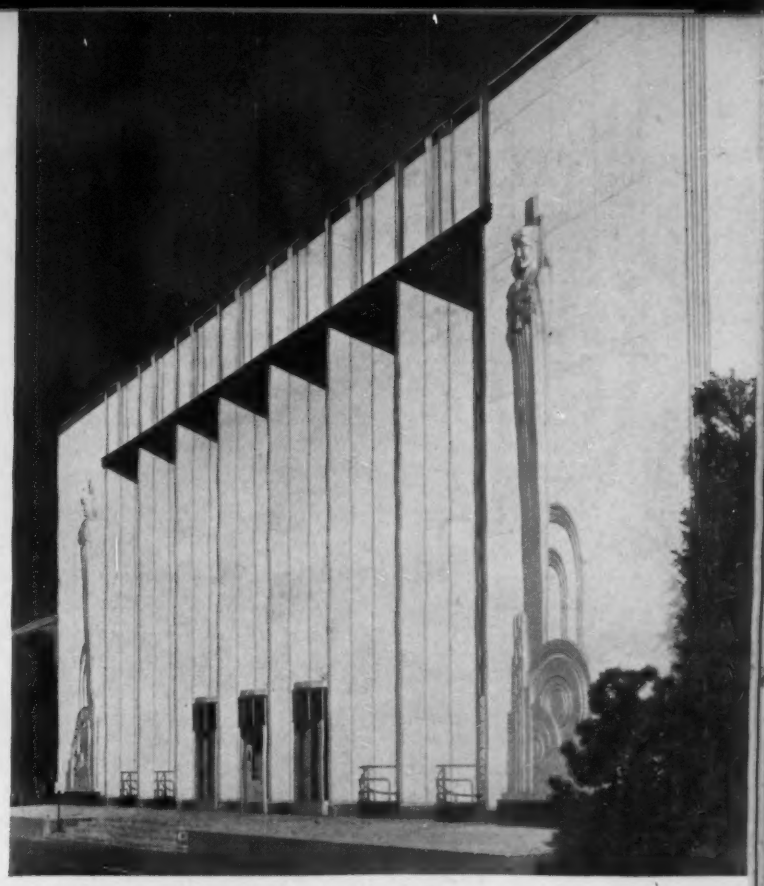
With this background we may come now to the attack on the problem of exhibiting mathematics in dynamic displays.

We acknowledge in beginning that of all the sciences, mathematics is the least adaptable to exhibition. It is perhaps the oldest science, but it is characterized by its perennial youthfulness. This attempt to visualize pure mathematics and bring her upon the stage in action may illustrate the thought, previously expressed, that the Exposition may have an influence on education.

Dr. E. T. Bell, in his delightful book "The Queen of the Sciences," states that, "of higher arithmetic the graduate of a good school will learn precisely nothing. Unless extremely fortunate, he will never even have heard of the theory of numbers."

A broad view of the science is seldom if ever given in any of our educational institutions. The student is given training in special tools as he proceeds on his path of knowledge. He progresses from algebra to geometry, from trigonometry to calculus. The last course usually offered is the history of mathematics.

It appears that a careful and studied effort has been made to withhold the beauties of "The Queen of the



Facade of the Administration Building of the 1933 World's Fa

Sciences" from those whose acquaintance with mathematics is a forced one and not the result of an interest awakened by her charms.

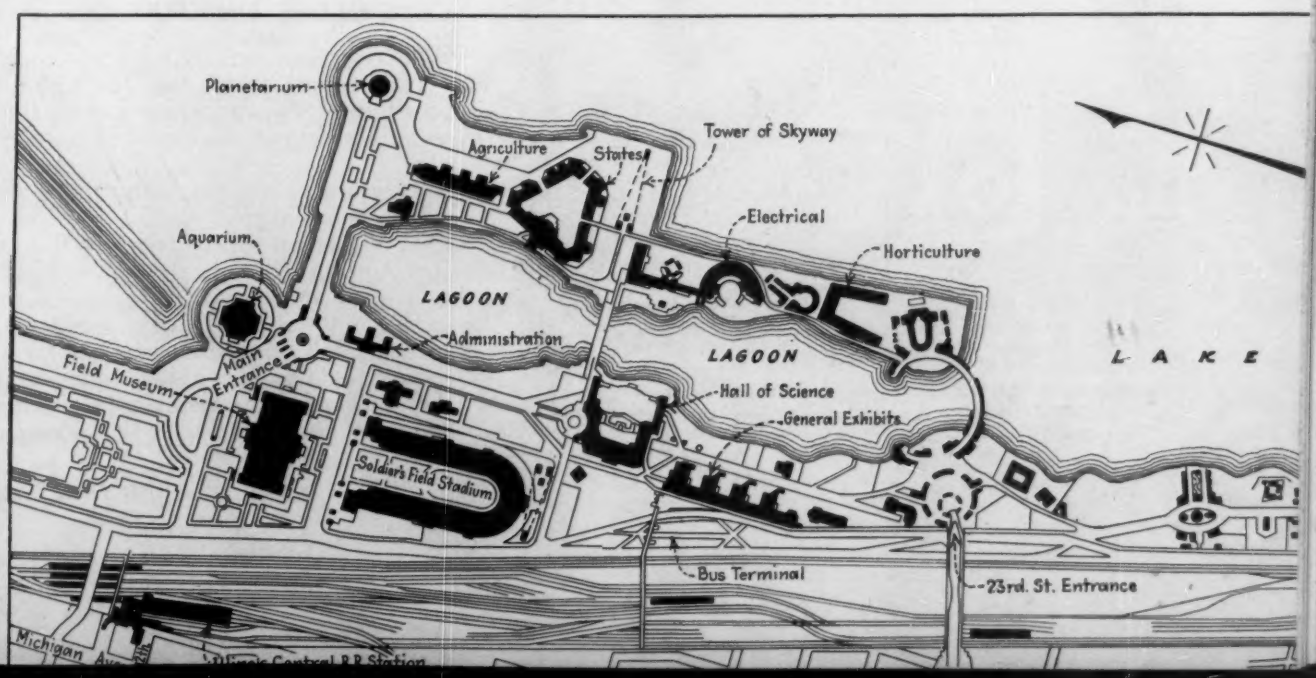
A conception of pure mathematics is seldom given or offered to the undergraduates of our higher institutions of learning. We are endeavoring to present to an audience of fifty million persons a picture of the realm over which rules the "Queen of the Sciences."

In the making of this picture some of the most distinguished mathematicians in the country have given generously of their thoughts and effort.

Mathematics has been divided into four major subdivisions for the purposes of exhibit. They are: numbers and algebra, geometry, analysis, applied mathematics.

As the visitor enters the North Lobby of the Hall of Science, he will behold in the center of the lobby a large octagonal prism, the design of which will suggest a structure of the Ancients. On the north, east, south, and west faces of the prism are screens on which are projected from inside the prism images from slides,

(*Continued on page 79*)



Map of the exposition grounds. The Hall of Science is in the center of the figure.

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EDITORIALS

OPEN HOUSE

THE guests whom the Institute is glad to have the opportunity to welcome to its Open House will probably find many questions to ask, questions seeking explanations of mystifying processes, odd phenomena, strange results derived from stranger means. It is to be hoped that they will not spare their hosts, but rather will be inexorable in demands for elucidation, and that more often than any other they will put the pragmatic query, "What's it good for?"

Ability of the host to give more than a surface answer to this question at the time will of course depend upon his knowledge of the subject and even more upon his previous consideration of the less obvious issues involved in it. After Open House is past, however, when the guests are gone and the business of study is once more in hand, the pragmatic query may be expected to come home with a special keenness to him as an individual.

As he thinks over Open House, and answers "What's it good for?" in retrospect, the Institute's representative, student or instructor, will have opportunity to evaluate for himself, not for a visitor, his school and the work he and it are doing. Going back through Open House day in his mind, he will have to take account of stock, examine his purpose in study or in teaching, and attempt as best he can to clarify the aims of research and the ends of education.

Opportunities for this sort of self-examination are few at best, and too often eluded by means of answers which try to justify the expenditure of time and effort by easy talk about the material gains to be expected from it by the individual. If on the contrary the occasions provided by Open House are put to honest use, the Institute's guests of a day will have left behind them perhaps more of profit than they take away.

COMPETENT INCUMBENTS

THE electoral system used in this country does not and cannot insure that the best qualified men will be elected. The candidate making the greatest appeal will probably win the election regardless of his inherent ability.

The students of the country may well interest themselves sufficiently in the future of our government so that its control will be removed from the hands of the incompetent. It is the duty as well as the right of those who have the benefit of higher education to take an active interest in political matters, to make their strength felt, and to ascertain as far as is within their power to do so, that those elected to public office shall be qualified by education to discharge their duties properly and with benefit to the majority.

OPEN HOUSE EXHIBITS

PHYSICS

For orientation, a few features of the George Eastman Research Laboratory may be mentioned. The lecture room on the first floor, classrooms on the second floor, the Forris Jewett Moore Room (a social room) and the Eastman Research Library for physics, chemistry, and mathematics on the third floor are the joint facilities of the two departments using the building. The various laboratories are scattered about the building.

The spectroscopy laboratory: Spectroscopy is peculiar among the branches of experimental physics in that it takes equipment that will not go into ordinary rooms. A grating spectrographic outfit requires a large dark room with unusual steadiness and constant temperature, the whole room forming the spectrograph. The only way to secure this here was to build a special spectroscopy laboratory in the court enclosed by Buildings 6 and 4, connected with the basement of Building 6 by a corridor. The spectroscopy laboratory required quite unusual engineering technique, in order to secure temperature insulation and regulation — there are eight inches of cork in the walls, the temperature inside would fall only a degree a month if the outside were at zero and all internal heat were cut off, and the thermostatic control is good to a tenth of a degree. Stability was also a considerable engineering problem because of the bad foundations, piles being necessary on the made land, and because of the nearness of streets carrying heavy traffic. The inside of the laboratory is isolated from the outside, with layers of sand and other materials between, and this effectively prevents vibrations from coming in from outside. Perhaps the best test of this is that the ore crushing machines in the end of Building 8, contiguous to the Eastman Laboratory, which produce a vibration that shakes their building from end to end, cannot be detected in the spectroscopy laboratory with a sensitive seismograph. Among the permanent equipment of the spectroscopy laboratory may be mentioned the twenty-one and thirty-five foot mountings with diffraction gratings, the twenty-one foot vacuum spectrograph, the two meter broad range vacuum spectrograph of Dr. Compton and Dr. Boyce, several types of interferometer, in charge of Dr. Wulff, and several microphotometers, for measuring the intensity of lines photographed on spectrum plates.

The spectroscopic interval sorter: One of the popular sports of the spectroscopists is arithmetic, and particularly subtraction. The result of a spectroscopic experiment is a table of wave numbers (reciprocals of wave lengths of spectral lines, enormous numbers of the order of hundreds of thousands, correct to a fraction of a unit). A fundamental rule of spectroscopy is that each observed wave number is the difference of two "terms," numbers representing certain states of the atom or molecule representing the spectrum. There are fewer terms than lines, for each term can combine with many others, so that a table of a hundred terms may be capable of explaining thousands of lines. And to find the terms, knowing the wave numbers, proves to involve subtracting all pairs of wave numbers, and finding any differences which occur many times. This seems simple, until one begins figuring out how many differences there are between all pairs chosen from a thousand lines. There are enough so that, with a complicated spectrum, there is arithmetic to last all winter. This situation led Professor Harrison to invent a machine, which in its ability to save the time of physicists rivals the wild dreams of the technocrats. It is a machine in which the observed wave numbers are punched as holes on a tape, the tape doubles over itself and is pulled along by a sprocket, and whenever two holes, in the upper and lower half of the tape, come over each other, a light shines through both the holes and strikes a sheet of photographic paper. The resulting photograph proves to have a black spot for each difference of wave numbers, and by observing which spots line up with each other, a winter's work is done in a few hours. Already the interval sorter has been applied successfully to a number of complicated spectra.

Dr. Compton's vacuum spectrograph: At the time the spectroscopy laboratory was opened, Dr. Compton and Dr. Boyce brought from Princeton a broad range vacuum spectrograph, looking, as some one described it, like a grand piano with a vacuum in it. Recently they have been obtaining very fine pictures, spectrum photographs of neon and other light elements.

ELECTROCHEMICAL ENGINEERING

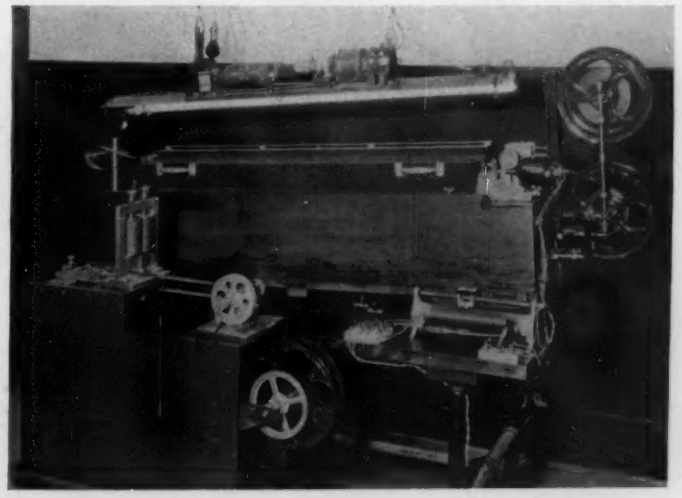
The principal feature of the Electrochemical Engineering Department's part in Open House will be the demonstrations of various electric furnaces in operation in 4–007, the furnace laboratory. During the afternoon the Héroult arc steel refining furnace will be run; and later the Kjellin low frequency induction furnace and the Ajex Northrup high frequency furnace will each be shown melting cast iron.

An exhibit of electrochemical products, such as electrically reduced metals, will be shown in Room 4–109. In the same room, students will work on thesis problems in electrolysis.

MINING AND METALLURGY

The Department of Mining and Metallurgy has well-equipped laboratories in which to illustrate the various operations and to carry out research in various fields. These laboratories may be seen on Open House day, and some of the apparatus will be in operation.

The latest instruments and methods of prospecting by geophysical methods will be demonstrated. By these instruments ore and oil deposits which show no evi-



The spectroscopic interval sorter, a mathematical machine which accomplishes a winter's work in a few hours.

dence of their existence on the surface may be discovered.

In the ore-dressing or concentration laboratory a gold stamp mill will be in operation, showing how gold may be recovered by crushing the ore and amalgamating the metal. Here also some methods for separating valuable minerals from waste rock will be demonstrated.

In the smelting laboratory the sintering of ore to remove sulphur and prepare the ore for smelting in the blast furnace will be shown. Here also is a small blast furnace, modified somewhat from those used in practice, but illustrating the principles of smelting. Coke and iron are fed at intervals in the top and the fused products withdrawn at the bottom. Dust and fumes are collected in a Cottrell electrostatic dust-catcher operating at 40,000 volts. This laboratory also contains furnaces and kettles for copper and lead refining which will be on exhibition but not in operation.

Filtering by means of an Oliver continuous filter will be shown in the wet metallurgy laboratory and here also the leaching of copper from ores by means of sulphuric acid solution. The apparatus here is similar to that used in practice but on a smaller scale. Apparatus for the electrolytic refining of copper will be on exhibition but not in use.

The assaying of gold and silver ores by fire methods will be shown in the fire assay laboratory. The equipment here is exactly like that used in practice and the methods the same. The precision of the work may be understood when it is realized that given an ore which contains only 1/100 of an ounce of gold in a ton, a sample of the ore weighing an ounce can be taken from it and the gold extracted from this portion and weighed.

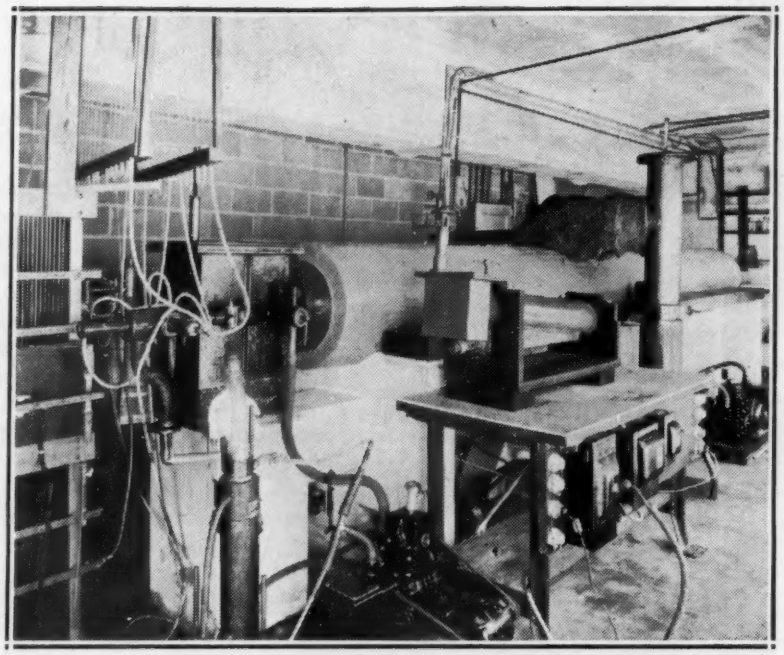
The microscopic examination of polished specimens of metals and alloys will be shown in the metallographical laboratory and the changes in structure due to heating and cooling at various rates will be observed. In the heat treatment laboratory the methods for producing these structures will be illustrated.

X-ray methods of examining metallic structures have come into prominence during recent years and the Department is well equipped with apparatus for carrying out instruction and research in these lines.

The mining and metallurgical industries are basic in modern civilization and the Institute has always been in the forefront in educating men to enter them.

CIVIL ENGINEERING

Modern practices in railroad operation are illustrated in striking fashion in the miniature railroad system built by students in the coöperative course in Railroad Operation maintained by M. I. T. and the Boston and Maine Railroad. This exhibit is one of the features shown in the Civil Engineering Department on Open House day. Careful attention to detail, particularly in signaling devices, is the distinguishing feature of this railroad layout. The latest developments of modern operating methods illustrated by this exhibit include: automatic color-light block signals operated by track circuits, automatic train control, automatic interlocking at track crossings, remotely controlled switches operated from a central control panel, and automatic highway crossing danger signals. Except for the use of standard miniature tracks and rolling stock, all other details such as color-light block signals, track circuits, control panels, etc., were prepared by students.



The Tech

The Physics Department's vacuum spectrograph.

The complete installation involved the use of about two hundred feet of two and one-half inch gauge trackage, more than two thousand feet of circuit wires, and nearly fifty relays. Three or four trains will be in simultaneous operation on the main line and on the branch, the switches of which are electrically controlled from a central point. To the layman, the most interesting features are probably the automatic train control whereby the trains are prevented from passing block signals indicating danger, and the automatic interlocking which controls the operation of trains arriving simultaneously at the "diamond" crossing. In addition to providing real entertainment for the many guests attending Open House, the entire layout represents the application of scientific knowledge and practice, and it is typical of the coördination of technical and practical information gained by students in this coöperative course.

ELECTRICAL ENGINEERING

The stroboscope developed by Professor Edgerton should prove to be an interesting and instructive exhibit. By means of this device it is possible to study the motion of objects both at low and high speeds. Motion pictures taken at the speed of one thousand pictures a second show that the initial spin which may be given a golf ball by striking it a bit below the center may be as much as three thousand revolutions *per second.*

In addition to the exhibition and operation of the numerous machines in the dynamo laboratory, there will be a collection of apparatus used when electricity was in its infancy. The display will show clearly the advances made in the design and construction of electrical machines.

In the networks analyzing laboratory the visitor will see the equivalent of hundreds of miles of wire lines. These networks are used to observe and study what will happen in power lines long before they are ever erected.

Of great interest to the public will be the uses of photo-electric cells to control and operate various instru-

ments and machines. In many of these exhibits use will be made of special types of vacuum tubes — some of which have been made in the electronics laboratory at M. I. T.

The differential analyzer on exhibit represents the height of ingenuity. By means of this instrument it is possible to solve problems in a short time which would take hours or even days to solve by ordinary methods.

CHEMISTRY

All the facilities of the Chemistry Department will be on exhibition on Open House day, with the laboratory work of the various classes in full swing as well as the research under way in the new Eastman Laboratories.

The freshmen will give lectures and demonstrations in lecture hall 6–120 of the Eastman Building. These are to be typical of the regular lectures on the subject given the freshmen, but they will be conducted with no help from instructors or upperclassmen. Such experiments as dyeing, thermite reactions, metal plating, silvering of test tubes, and rate reactions are to be shown.

The juniors will carry out such experimental processes in organic chemistry as synthesis, vacuum distillation, and organic analysis in Room 4–440. Work on such phases of theoretical chemistry as solubility, conductance, and transference will be done in Room 4–453. Seniors will conduct their thesis work in many of the department's rooms.

The oil analysis laboratory, 4–047, will be open to carry on gas calorimetry, oil analysis, and gasoline distillation. Latest methods in the determination of the purity of various common foods will be shown in the food analysis laboratory, 4–059. Measurements of the density of carbon dioxide under various conditions will be carried on in Room 4–459.

BIOLOGY AND PUBLIC HEALTH

Visitors to Open House will be able to see a large number of exhibits representing biological materials, specimens and processes from all over the world in the Department of Biology and Public Health on the fourth floor of Building 10.

The botanical and zoölogical exhibits in Room 10–419 include plants and animals from the lands, waters, and skies of many countries. The anatomy laboratories, moreover, with their slides and microscopes, offer rare opportunities for the visitors to explore the make-up of various living things. These are in 10–479.

A small model fish hatchery will demonstrate how it is possible to raise brook trout and salmon to restock our depleted streams.

The bacteriological exhibits in 10–475 will include demonstrations of some of the methods used to test the purity of milk and water supplies. Models of the filtration units for water purification and sewage treatment plants will be shown. Numerous exhibits under microscopes will show various kinds of bacteria which cause disease in humans.

The food technology laboratories, 10–470, will have in operation a small working model of a Birdseye plate-freezer, one of the most recent and revolutionary processes for the quick freezing of foods. An exhibit of a number of foods frozen in commercial apparatus of the same type has been arranged.

Also in Room 10–470 there will be exhibits of the industrial microbiology, the nutrition, and the biochemical laboratories. The first-named will show a number of fermentation processes which use bacteria and yeasts to form chemical compounds such as acetone, butyl alcohol, and glycerin from sugars. Molds that can grow in sugar and produce citric acid (the same as in oranges and grapefruits) will be shown at work. The nutrition and biochemical laboratories have collaborated to produce an exhibit including the apparatus and tests used in evaluating the nutritional qualities of foods, vitamins, and digestive agents. Some of the animals under test may be seen.

CHEMICAL ENGINEERING

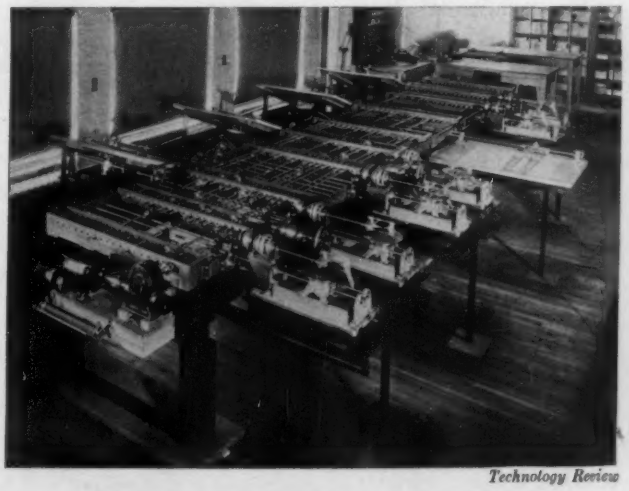
The Chemical Engineering Department will carry on many typical processes in applied chemistry for the benefit of visitors to Open House. Heat transmission, cracking and catalytic processes as portions of thesis work will be in operation in Room 2–110. A rubber plant will be in operation in Room 2–025, and the laboratory on internal combustion engines will be open. The research laboratory of applied chemistry, Room 2–019, will carry on various processes. A few of the lecture demonstrations used for instruction in the Chemical Engineering Course will be carried out.

MECHANICAL ENGINEERING

Even while the student is mastering the fundamental sciences, such as Physics, Chemistry, Mathematics, he starts training in mechanical and machine drawing. The mechanical engineering drawing rooms are located on the fourth floor of Building 3. The visitor will find there a very complete exhibit of student drawings, and also an exhibit of the more advanced work in machine design.

Passing to the next floor below, we first find the textile laboratory. This laboratory embraces a full complement of testing machines with capacities from one and one-half ounces to two thousand pounds. All machines are equipped with an autographic apparatus for recording graphically the stretch of the fabric under test. The visitor will be particularly interested in the optical testing of fabrics. A microscopic view of fabric testing by the use of polarized light will be thrown on a screen, showing the beautiful color scheme attained when the fabric is stressed under the beam of light.

Just around the corner from the textile laboratory, we find the large machine tool laboratory, devoted entirely to instructing the student in the use of the one hundred ninety odd machine tools installed in this room.



Technology Review

The differential analyzer, a mechanical mathematician.

Each visitor is assured of a complete description of any machine by the student operator. We wish to call particular attention to the precision measuring machines, used by the students in their work. One fine measuring instrument uses the diffraction of light waves to measure to one millionth of an inch. There will be several of the advanced students in charge of the sixteen-inch sliding gear head lathe, used for testing tungsten carbide cutting tools. These tools are used extensively in the automotive industry on production work.

The testing materials laboratory occupies four floors of one large section of Building 1, adjoining Building 3. These laboratories are equipped with modern machinery for testing practically any material used in engineering. The capacities range from one million pounds down. The million-pound machine is located on the first floor. The hardness room, on the second floor, contains many machines used in testing the hardness of materials. The testing of stress in complicated sections is accomplished by the use of the photo-elastic method. Celluloid replicas of the test piece are mounted in the photo-elastic machine in a dark room and the analysis made by the use of beams of light. The concrete testing is done in the basement of the same building. Every modern device for testing concrete in any form will be found in this department. Members of the instructing staff will be in attendance throughout the day to supervise the operation of the machines which will be operated by the students. Large wooden beams will be broken at regular intervals throughout the day.

Occupying the first and basement floors, and the second floor gallery are the steam, hydraulic, and compressed air laboratories. A series of tests will be run on various machines, notably the triple-expansion Corliss steam engine, and the Morgan-Smith hydraulic turbine. This turbine is a duplicate of the large vertical water turbines used in the large hydraulic water-power stations throughout the country. It will be interesting to look for the hydraulic measurement devices in operation. These tests are a part of the regular course of instruction. Guides will point out and explain all the apparatus, every piece of which will be running.

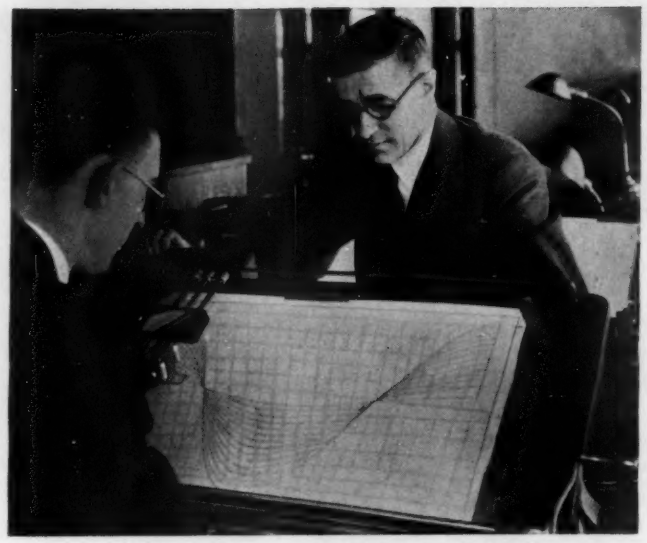
The remainder of the engineering laboratories are located in separate buildings on Vassar Street. The power trip hammers will be in operation in the forging laboratory and the various moulding machines in the foundry. The cupola for melting cast iron may be seen and guides will explain its operation. The refrigeration and air-conditioning laboratories are located in a separate building two hundred yards nearer Kendall Square, on Vassar Street. It is hoped that a large number of visitors may find it convenient to visit this department because of the very important part that these processes are playing in our lives today.

MATHEMATICS

The Department of Mathematics will present displays and demonstrations of mathematical instruments. Calculating machines of several types and designs will be fully demonstrated as will the Chinese and Japanese abacuses. Slide rules of unusual types and designs, such as the cylindrical slide rule, will also be on exhibition.

The department will demonstrate the use of a harmonic analyzer of latest design and high accuracy. Also, with the aid of light, demonstrators will perform experiments with models of well-known peculiar geometric surfaces. Student-made alignment charts, representing a large variety of engineering formulae, will be on exhibit.

The demonstration will be rounded off with exhibits



A set of curves drawn by the differential analyzer.

of historic books and facsimiles of original papers on classical problems, and lantern slides on miscellaneous mathematical subjects.

BUILDING CONSTRUCTION

Professor Voss, who is studying the manufacture of the ordinary brick, expects to have his work set up during Open House so that all who are interested may see the steps taken during the investigation of a brick and mortar combination. The study of the brick's structure, the determination of its coefficients, the study of the mortar structure and its coefficients, the making of assemblies, their tests, and thin sections of these structures under the microscope will all be illustrated. The process will be repeated several times.

On Open House day there will also be moving pictures in Room 5–229 showing construction methods and the manufacture of certain building materials. In Room 5–240 there will be an exhibit of samples of many building materials and details.

AERONAUTICAL ENGINEERING

The two largest wind tunnels in the Guggenheim Aeronautical Laboratory will be running full blast on Open House day. The seven and one-half foot tunnel is to be used to measure the distribution of pressure on an airfoil section. The complicated apparatus set up by several undergraduates working on their theses will be employed. In the five foot tunnel a model airplane is to be put through a series of tests. The plane will be kept in balance at different wind velocities by an automatic system of electric motors. Further tests on streamline designs will be made by dragging the different shapes through a tank of water. The path taken by the water as a body goes through it will be shown by aluminum filings sprinkled on the water.

On the third floor in the rigging room the Aeronautical Engineering Society will have its gliders on exhibit. The new soaring glider, which may be used this summer at the Elmira meets, is in very good condition. The veteran secondary ship now being rebuilt by the students is equally interesting, since it shows clearly the details of construction. Around the room will be displayed various small parts and fittings of airplanes, and in the drafting rooms student drawings are to be posted.

SCIENCE AT THE WORLD'S FAIR

(*Continued from page 73*)

which give the progress made through the ages in the subdivisions mentioned above.

These slides are being prepared by Prof. Louis Karpinski of the University of Michigan. Almost a year has been taken up in their making. Their range of interest is wide. The school child of ten will enjoy the spectacle and will sympathize with the little Roman who had to compute with the abacus. The interest of his elders may be taken for granted.

A visit to the geometrical exhibits will be rewarded by a most spectacular display of Pollock's Models. Here, ever-changing surfaces of light will intersect string surfaces in motion. The curves of intersection will stand out as if made of incandescent wires.

Those who have with closed eyes and bowed heads tried to visualize the figures and curves met in higher plane curves will groan in the agony of regret that this presentation was not available in freshman days. Our old friends the "conic sections" have not been forgotten. The ellipse degenerating into a circle and into a double straight line will be shown in a setting of dignified beauty.

Solution of a differential equation of wave motion by D'Alembert in 1747 will be presented as the starting point of radio communication in an exhibit showing the relation of mathematics to the development of radio. Historic apparatus loaned by the United States Navy will illustrate radio's progress. A gyroscope compass with "repeaters" will be installed in the Great Hall of the Hall of Science. Instruments used by the Navy in navigation, gunnery, and communication will show the indebtedness of our "first line of defense" to mathematics. Capt. Frank H. Roberts, U. S. N., the Navy representative at A Century of Progress, is the head of the mathematical section.

The Queen exchanges her regal robes for the garments of a servant and is, in another booth, the handmaiden of the sciences. The application of mathematics to Economics is shown in the presentation of the Law of Supply and Demand.

The school boy looking for action and motion may climb aboard a revolving platform near which is the imposing title "The Conservation of Rotational Momentum." The professor of physics will be interested in the derivation of the expression for rotational momentum, which is given in the legend.

Wherever possible the principles illustrated are connected with the individual who discovered or enunciated the principle.

It is our hope that the visitor will be led to the view that "the deliberate attempt to create something of immediate utility leads as a rule to shoddy work of only passing value." He will agree with Jacobi that "the true end of mathematics is the greater glory of the human mind."

If our presentation of the basic sciences fulfills our hopes, it is not unreasonable then to think that although there may be no Royal Road to knowledge, at least there is a road, parts of which are broad highways, at A Century of Progress.

LEWIS E. MOORE

American Society of Civil Engineers
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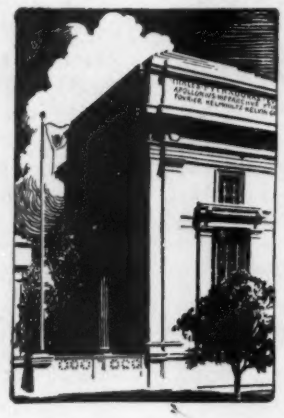
UNDERGRADUATE ACADEMIC OPPORTUNITIES

(*Continued from page 69*)

ing thing to work toward a definite objective. Moreover, there are significant differences in the aptitudes of individuals, and these must be recognized early if time is not to be wasted. At present we have no sure way of measuring these aptitudes, and we must simply recognize them as best we can on the basis of progress and of likes and dislikes. Some day it may be possible to make simple and reliable tests to determine such matters, and something has already been done along these lines. Undoubtedly, however, it will always be necessary to offer a great many diverse lines of activity because of the wide variation in the natural aptitudes of the human race, and we must seek to perfect our systems of choice and guidance in order that those who may excel in one line shall not fritter away their resources in some other which calls for utterly different methods of thought.



Thus, there is a possibility for study and progress in all sorts of fields. Most important, there is the opportunity for contact with outstanding masters in very diverse lines of accomplishment. It is only in complicated and well-endowed institutions that there can be a large number of staff members of national and international reputation, for such men are creators and they are to be found in those places where the atmosphere is most favorable to creative effort. One important thing for the undergraduate to look forward to is intimate and personal contact with outstanding staff members, who are recognized authorities along the lines where his interests lie. These men are pushing forward into unknown and difficult fields, and contact with them is invigorating and, in the highest sense, educational. Such contacts will be welcomed by the staff but must be sought by the student. They cannot be made automatic. It should also be noted very definitely that when it is stated that such men are creators, it means more than that they are all research professors in the physical sciences; some of them are writers and research pioneers in all kinds of scientific and technical fields; some of them have had and now have important contacts with industry from which they draw much of breadth and knowledge of the affairs of the world, which they are eager to pass on to the coming generation; some are students of pedagogy in its most intimate sense; all of them are teachers.

The ratio of students to staff at Massachusetts Institute of Technology is very low in comparison with the average throughout the country, about 5.4 in 1931–32, in comparison with an average of 12.2 for 594 colleges and universities. There is a great deal of research going on within this institution, both by students and by staff, for it is only in an atmosphere of progress and of pioneering that the highest type of instruction can be offered to those who are aiming at outstanding success in their professional careers. This research is not necessarily experimental for it includes economic research, research in literature, research in the fundamentals of design, and all sorts of activities in which creative minds find an outlet. The members of the staff are themselves students, and they continue to be students throughout their lives. Some are studying the humanities; some are studying the applications of the laws of nature for the benefit of man; and some are finding new laws. Together with the student body they form a group of men dedicated to the advancement of knowledge and its unfolding to the coming generation. Of course, all this is expensive, and the Institute expends about $1,000 per year per student in its activities. In one sense, we may say that our tuition is $1,000 per year and that we give every student a $500 scholarship. This is what actually occurs, although the actual mechanism avoids the formality of charging the extra $500 and then returning it. In addition there are scholarship funds amounting, for undergraduates, to about $75,000 annually, and these are used for the reduction of the $500 tuition. Moreover, there is the Loan Fund, from which about $200,000 has been loaned to students through the present academic year, to enable them to carry on in cases where the residual cost to them would otherwise be prohibitive. Thus, the Institute through its endowment and its Loan Fund carries as much of the burden as is possible, realizing that the total cost is high, but with firm conviction that the result in the long run justifies all that it costs. It is a great satisfaction, in view of the presence of the Loan Fund, to realize that it is now possible for a student who makes good academic records, but who is short of funds, to proceed with his studies without paying anything whatever to the Institute, deferring his contribution until he is out in practice. The loans are reserved to those who, from all points of view, are promising, in order that no man shall be given a loan who is not destined for success in his profession, for the loan must revolve, and the payment must not be an undue burden.

At the present time, there is a distinct tendency toward a liberalization of the curriculum. Faculty committees are working on this matter intensively. Probably the amount of study and effort that goes into this investigation would be quite surprising to the average undergraduate. There is an effort on the part of the Faculty to reduce the amount of definite assigned burden on those undergraduates who can profit from a release from detailed control. This is a move away from the situation which exists where every bit of academic work by an undergraduate is the result of a specific daily assignment. The Faculty has made several moves in the direction of lifting this detailed supervision. It goes forward with caution, for not every student can profit from increased freedom. There are still some who will work only under specific daily assignments. Such, it is probably true, have comparatively little likelihood of success in their professional careers, for their progress after graduation must be a matter entirely of their own initiative. The student who needs close supervision is probably misplaced and is not studying the things in which he finds the greatest interest, or else he has no real interest. The release from daily assignment, and the substitution therefor of greater opportunities for consultation with the staff in small groups and on matters of special interest can go forward only as fast as the student body itself makes this possible. This involves two things which may well be given very serious study by any undergraduate. The first is a better study of aptitudes, a better selection of a career so that study may be pleasant and welcomed, and activities may lie in a field of intense and intimate interest. The second is a growth in maturity of the undergraduate body so that students may be ready to accept, to a greater extent than at the present time, the responsibility for their own progress, and take, themselves, the initiative in the formulation and pursuit of their undergraduate academic careers.

FUTURE OF THE INSTITUTE

(*Continued from page 66*)

it is now privileged to possess, as effectively as possible. As I have come to know my colleagues on the Corporation, the staff, the alumni, and the student body, I feel confident that this aspect of our future will be well taken care of.

Beyond this, it can only be said that the effectiveness of our work could be extended in many directions if our facilities were suitably extended. I can mention only a few illustrations.

Our general activity in research, and particularly the frequent occurrence of really major projects whose possible development stirs the imagination, emphasize the extent to which a really adequate endowment for research would strengthen our permanent program of education and public service.

The most important element of our program is the maintenance on our staff of such recognized leaders in the scientific, engineering, and architectural professions as well insure that effectiveness and prestige necessary to all aspects of our work. We need, therefore, a certain number of endowed professorships of great distinction similar to that whose undertaking was recently announced in honor of Elihu Thomson.

In order to give more adequate scope to our fine development of student activities which can do so much to develop traits and viewpoints which will make future better citizens, a certain amount of physical equipment could be used to great advantage. This equipment includes the projected extension of the Walker Memorial as a center for student activities and the provision of more adequate quarters for athletic sports, which are now cramped to the extent of limiting participation.

There are several aspects of science and engineering which have recently come to be of great importance and for which the Institute is not adequately equipped. These include such subjects as hydraulics, cryogenics, high-pressure investigations, graphic arts, and increased attention to economic aspects of architecture. Many other desirable extensions of our work might be added to this list.

The research activities which have been carried on by the Institute at Round Hill, with the support of Colonel E. H. R. Green, suggest a number of ways in which an experiment station of this type could be further developed to supplement the regular work at the Institute and at the same time to provide new opportunities for public service in other directions.

In conclusion I should emphasize that while the items suggested above would provide desirable directions for the Institute's growth, by far the most important element for the future is wise and sturdy adherence to the ideals which have from the beginning been the motive, power, and inspiration for all of those members of the Institute who have contributed so loyally to their realization.

RESEARCH AND THE MANUFACTURER

(*Continued from page 70*)

The questions of time and facilities may be considered briefly and together, since in a well-organized laboratory no one is merely waiting for a problem to come in, and no equipment completely adapted to any problem is kept ready. As an operation preliminary to providing help or research, some member of the staff must be found who is willing to lay aside his regular work or direct new work as an overload for a short period, and frequently this is out of the question. Occasionally, too, a thoroughly qualified member of the staff is already retained by a competitor, and for this reason proffered work must be declined. In the greater number of instances it is possible to arrange for the research, provided that a little patience can be expected from the manufacturer.

It is profitable to inquire first what the directors of research may reasonably expect from the manufacturer, and second, what benefits he may expect to derive from the research, though these questions are commonly considered in the reverse order. Mutual coöperation and mutual frankness are so obvious as to require no words. It *seems* obvious that a clear statement of the problem, together with a careful limitation of its scope, should be easy to formulate, though experience shows that this is not always true. Frequently the measurements finally agreed upon are not those called for in haste when the problem was first submitted, and the first experiments suggested would not have contributed much to the solution of the problem if they had been performed. If the manufacturer relies upon the laboratory to state the problem or to read his mind in regard to expectations, delay and misunderstanding are almost inevitable.

If the problem as finally stated requires for its solution only the adaptation or combination of experimental means such as electrical measurements, chemical analyses, X-ray or microscopic examination, strength tests, temperature control and measurements, results usually accumulate shortly after work has started, and a first explanation of difficulties is soon attained. Under these circumstances, very little that could honestly be called research enters into the matter

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OTTO K. EITEL, *Manager*
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RESEARCH AND THE MANUFACTURER

(*Continued from page 81*)

at all, but it may not be advisable to press the definition. Work begun along these lines frequently develops into real research without a perceptible transition.

Problems are rarely so simple, however. When new experimental procedures or chemical controls must first be devised or tested, and especially when new instruments must be designed or constructed, delays are likely to arise despite the greatest care on the part of the experimenters.

The recent transmutation of lithium and boron into helium may be mentioned as an illustration of the way in which one discovery must wait upon another, even though atomic transmutation is still far from an industrial problem. The alchemists who attempted transmutation with inadequate instruments, fantastic procedure, impure reagents, and no chemical controls may honestly claim to have tried all the means then known to "science," but perseverance without adequate support from knowledge failed miserably. For one reason, they began on a very complex atom (gold) without any study of simpler ones, partly because they had no means of knowing which elements were simpler than others. Prout's hypothesis was proposed many centuries later, giving the first hint that transmutation was to be thought of in terms of hydrogen, rather than gold. Not until the beginning of the twentieth century did the discovery and study of radio-activity, the ionization of atoms, the proposal of an atomic nucleus and a reasonable theory of its structure, begin to supply the necessary "tools" and the requisite knowledge. Even then, alpha particles from radio-active disintegration were the only means of shattering simpler atoms such as nitrogen, but shortly after Sir Ernest Rutherford had announced this discovery, many workers were "on the right track." Yet final accomplishment of atomic synthesis had to wait another decade while protons were being studied, and while means of giving them sufficient velocities were developed. This was really a development rather than a discovery, for it depended much more upon the improvement and extension of known experimental means than upon finding some new basic fact. Yet during this "development," and closely associated with it in the same research laboratory, an entirely new fundamental discovery of the very greatest importance was made, namely, the "neutron" was found and identified.

Industrial researches seldom touch the very foundations of scientific knowledge in such a striking way as has just been described, and seldom require so much support from science. They are commonly based upon applications or adaptations of methods which are fairly well understood. But anyone undertaking research, industrial or otherwise, should be prepared to turn aside from the original main line of attack for a really important discovery, quite as much as he should avoid this temptation when trivial matters seem attractive for the moment.

By way of summary it may be said that a manufacturer proposing a problem must clearly state it, exercise patience while it is being investigated, provide sufficient means for its conduct, and submit it to a laboratory qualified to do the work.

The greatest responsibilities which rest upon the laboratory accepting the work are: (1) the selection of experienced men to direct the work and provide supporting knowledge, (2) the assignment of assistants of sufficient skill and enthusiasm to prosecute it, (3) the providing of space and laboratory facilities with which to work, and (4) proper and constant coöperation between the research staff and the manufacturer as the work progresses.

Assuming that all of these conditions have been met, and it seems like assuming a good deal in a preliminary way before discussing final results, what may the manufacturer expect? He may expect research to proceed with reasonable freedom from the disappointments and financial shocks attending rash attacks upon any problem, or considered attacks upon the wrong problem. He may see active young scientists at work; he may coöperate with them to his own benefit, and he may even catch their enthusiasm. He may judge their fitness for places in his own organization if the work makes it desirable to have them. And unless he has proposed an insoluble problem, he may confidently expect to have it answered.

HISTORY OF OPEN HOUSE

(*Continued from page 67*)

varsity crew race with Princeton was held on the Charles River. A prize was given to the author of the best Tech Show skit written especially for Open House.

The eighth Open House was hardly known as such since it occurred in June 1930 when Dr. Compton was inaugurated president of the Institute. The 1930 five-year alumni reunion took place at the same time so that the entire Institute was thrown open for this large number of alumni and visitors.

Previous to 1931 a faculty committee had always been appointed which actively assisted the Combined Professional Societies in planning Open House. However, a tendency grew from year to year to permit the students in the professional societies to take care of more and more of the details of the annual affair until in 1931 the Faculty Open House Committee dissolved of its own accord at its first and only meeting.

From the viewpoint of attendance, the 1931 Open House exceeded all others with a throng of twenty-three thousand visitors attending. Compare this with the six hundred visitors who attended the first Open House nine years before!

In celebration of the centennial of Michael Faraday's discovery of the principle of electromagnetic induction, the Electrical Engineering Department had a particularly interesting and spectacular series of exhibits, with a special display in the Main Lobby of duplicates of apparatus used by Faraday.

Perhaps the one single exhibit which was enjoyed by the most visitors was the model railroad made by students in the Civil Engineering Department. The system was automatic in every detail. This same exhibit is at this year's Open House with even more elaborate arrangements.

The Open House Committee for this year's annual visitors' day has planned on twenty-five thousand people attending. Almost every course and department in the Institute has some exhibit particularly pertaining

HISTORY OF OPEN HOUSE

(*Continued from page 83*)

to it. The dedication of the new George Eastman Research Laboratory of Chemistry and Physics took place several days ago and exhibits used at this time have been made even more spectacular for Open House. As examples of the kind of demonstrations which one may expect, the following are listed: Dr. Bennett's apparatus for detecting the presence of cosmic rays, the bombarding of metal films by electrons traveling at one-third the velocity of light or 62,000 miles a second, photo-elasticity experiments by which stresses and strains in materials are detected, and the blast furnace operation in the metallurgical department.

A panorama of student life is obtained by viewing the many demonstrations of student activities presented in Walker Memorial, on the Charles River, and on the Athletic Field. At three o'clock the famous Technique Rush, which has always been a feature of Open House, takes place. In the evening the Musical Clubs, Dramashop, and Tech Show are each presenting a short entertainment especially prepared for Open House. A track meet with the University of Maine, crew races on the Charles, and exhibitions of boxing, fencing, and wrestling will give visitors an idea of the many sports indulged in by the students. In the afternoon, the Walker Memorial Gymnasium is the scene of a Tea Dance to which all are invited.

Students and Faculty alike have striven this year to make Open House as attractive, interesting, and educational as possible. The Faculty members of the different departments have always been on hand with helpful suggestions when students were planning the exhibits. Officers of the administration, heads of departments, professors, and instructors will be in their respective offices at various times during the day in order that guests, particularly parents of the students, may become personally acquainted with them.

AIR CONDITIONING IN THE HOME

(*Continued from page 71*)

hind a grill set in the walls. Some of the fan and radiator units are mounted in the wall, but more often they are put in cabinets which are placed in the room. The cabinet installation is more easily adapted for use in existing homes. The advantage of the centralized device, besides that of increased efficiency when a number of rooms are being conditioned, is that the heating system for winter use can be readily adapted to utilize the distribution apparatus, thereby avoiding the necessity for installing anything other than a boiler for heating in new houses. The accompanying diagram illustrates this method quite completely.

The unit coolers, of which one is installed in each room to be processed, are probably most suitable for installations where only one to three rooms are to be cooled or for installation in an old house, since they can be placed almost anywhere. When only one or two rooms out of four to six equipped are to be conditioned at one time, they are superior to the centrally located unit, for it is necessary only to run one or two small machines instead of one which is probably five times as large. Another advantage of the smaller unit is that it is possible to install more units at a later date without disturbing any of the existing apparatus.

With some of the cooling units the phase of humidity control is taken care of; others require the inclusion of a separate unit to maintain a proper water content in the air. A humidifying unit which is capable of operating separately from the cooling device is of great advantage, for then it is possible to run it in the winter and to provide the necessary moisture in the air.

The supply of refrigerant in the central system can be supplied from several sources. For cooling the circulating water or air, a unit similar to those used in refrigerators, but larger, can be employed successfully. These depend upon the principle that when a gas in the liquid state passes into the gaseous state, it absorbs heat and cools the surrounding mediums. Aside from the compressor used in this machine, there are few moving parts.

The steam ejector type of machine is another type which can be used satisfactorily in the home. Steam injected into a venturi tube at high velocities creates a vacuum in a chamber, giving the water therein contained a boiling point of from 40° to 60°. The water as it evaporates cools the remaining water which is circulated through the air conditioning devices. The main advantages of this machine are that there are no mechanical devices outside of two small pumps for circulating water and that the boiler used for winter heating can be used to generate the steam for summer cooling.

The use of ice is a simple way to overcome the problem of obtaining a refrigerant. Its use does away with the need of mechanical refrigerating devices, and thereby it lowers the cost of the machines, but its cost of operation seems to limit its use to special circumstances in which it can be used to good advantage.

The local unit coolers because of their limited size employ the gas expansion compressor discussed under central systems. The best models of this type are noiseless in operation and present a pleasing appearance.

One manufacturer has introduced a fan system which deserves mention. A fan is installed in the gable of the house and is used to draw off the heat which is absorbed from the sun and collects in the upper rooms. By drawing off the hot air before it penetrates the house and by causing a circulation of air, the inside has no chance to get warmer than the outside air. The circulation of air thus provided causes a rapid evaporation of the moisture of the skin with its accompanied cooling effect. The small electric fans used in the summer are an example of this process on a small scale. The installation and operation of this device cost less than that of other types.

In conclusion, it can be stated that local unit coolers are well suited for installation in old dwellings and where only one or two rooms are to be conditioned at one time. For new houses the central heating and cooling system is most appropriate unless it is desired to condition air only in a limited number of rooms. The choice of the several types of cooling depends upon the money available for investment and the preferences of the owner.

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Working out new ways to serve the communication needs of the public is an objective always in the minds of Bell System men. The new Teletypewriter Exchange Service—typing by wire—is an example.

For some years Private Wire Teletypewriter Service has speeded communication between separated units of many large organizations. Telephone men—anxious to make this service more widely useful—have now established Teletypewriter central offices, through which any subscriber to the service may be connected directly with any other subscriber. Both can type back and forth—their messages being reproduced simultaneously at each point.

This new service provides fast, dependable communication and does for the written word what telephone service does for the spoken word. It is one more Bell System contribution to business efficiency.

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G-E *Campus News*

IN A PADDED CELL

RESEARCH moves in devious ways its wonders to perform. G.E. has a padded cell in its general engineering laboratory at Schenectady—for the isolation of extraneous sounds. Confined in it, at intervals, are motors, fans, and other equipment which serves best when heard least. The cell is a room within a room. The outer wall is of sound-absorbing plaster; then come hollow tile, air space, felt, another layer of plaster, more air space, sheet iron, air space, lathwork, and a thick layer of cotton waste. Total thickness, a foot and a half. Within the chamber a "noise meter" tracks down outlawed decibels.

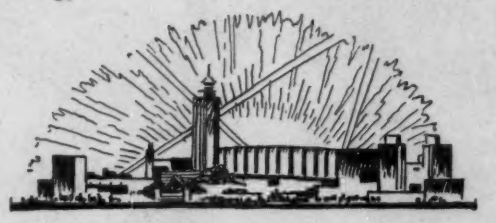
Last year, the noise meter left its padded cell and traveled to Manhattan's Metropolitan Opera House. Ensconced in a grand tier box next to that of Manager Giulio Gatti-Casazza, it measured voices, orchestra, and applauding hands while "Rigoletto" was sung. The meter discovered that Beniamino Gigli registered 77 decibels,—a street car in full progress makes only 65. Laboratory devices do have their big moments.

FORE!

"WOW! What a drive! If I could hit 'em like that, I'd sure break a hundred." Just a few comments as a national driving champ smacked a golf ball out of sight. Occasion—the demonstration of a new G-E device for measuring speeds heretofore not measurable because of their nature. The apparatus registered the speed of the champ's club head at 125 miles per hour; an average player is lucky to register 70. No wonder the champion can hit them so far.

The ball is driven from a low platform. Just back of the ball, two parallel beams of light are at right angles to the path of the club head. Each beam hits an "electric eye" or photoelectric tube. A split second before striking the ball, the driver cuts the first beam, and almost immediately afterwards cuts the second beam. Both phototubes operate Thyratron tubes, the first one causing a condenser to begin charging and the second one stopping it. The charge is measured by a meter which is calibrated in terms of miles per hour.

And don't worry about swinging too fast. H. W. Lord, who perfected the apparatus, says it will measure speeds up to about a thousand miles per hour. What a drive that would make! Incidentally, Lord is a '26 grad of the California Institute of Technology.



"A CENTURY OF PROGRESS"

THIS summer, if you go to Chicago, you will visit an Aladdin fairyland; "A Century of Progress" will be the greatest night exposition ever held. You will see a veritable aurora borealis, artificially produced. Walter D'Arcy Ryan, veteran G-E illuminating engineer, is working in Chicago to help make the exposition the most spectacular ever seen. And well qualified for the job he is. An engineer-artist—schooled at St. Mary's, in Halifax—he has directed the illumination for many similar events. When you go to Chicago, you will agree that a masterpiece has been created.

And you should not miss the G-E "House of Magic," the most amazing part of the General Electric display at the exposition. There, recent discoveries and developments of our Research Laboratory will be presented in a fascinating manner. "Bill" Gluesing, a '23 grad of the U. of Wisconsin, will have charge of the lectures and demonstrations. In addition, many G-E machines and appliances in the great circular hall of the electrical building will dramatize the rapidity of electrical progress. We'll see you at the exposition. Remember, it's from June 1st to October 31st.

95-990DH

GENERAL ELECTRIC